



# Commissioning and Recommissioning

- What it is
- The process
- The issues



**System WorCx**

Building Performance at the Next Level

# What is Commissioning?

Ship naming and launching endow a ship hull with her identity, but many milestones remain before she is completed and considered ready to be designated a commissioned ship. The engineering plant, weapon and electronic systems, galley, and multitudinous other equipment required to transform the new hull into an operating and habitable warship are installed and tested. The prospective commanding officer, ship's officers, the petty officers, and seamen who will form the crew report for training and intensive familiarization with their new ship.

Prior to commissioning, the new ship undergoes sea trials during which deficiencies needing correction are uncovered. The preparation and readiness time between christening-launching and commissioning may be as much as three years for a nuclear-powered aircraft carrier to as brief as twenty days for a World War II landing ship.

Source: Wikipedia



# What is Commissioning?

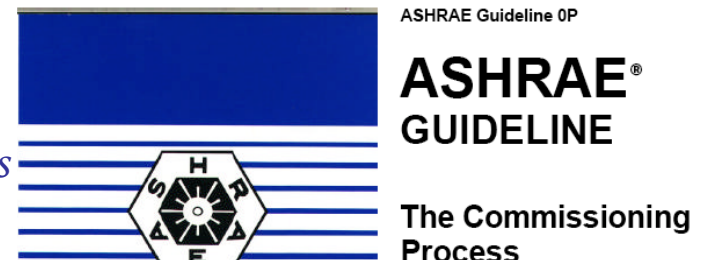
Building commissioning is a systematic, intensive quality assurance process that ensures a building's compliance with the Owner's Project Requirements (OPR). The benefits of proper commissioning begin with a more efficient, collaborative design and construction process and continue throughout the life of the building with greater energy efficiency, enhanced safety, and lower operation and maintenance costs.



# What is Commissioning?

A quality-focused process for enhancing the delivery of a project. The process focuses on verifying and documenting that the facility and all of its systems and assemblies are planned, designed, installed, tested, operated, and maintained to meet the Owner's Project Requirements.

*ASHRAE Guideline 0, The Commissioning Process*



# What is Commissioning?

1. Help the Owner identify how they need the building to perform.
2. Make sure the building is designed to perform to those needs.
3. Make sure the building is built to perform to those needs.
4. Make sure the Owner can keep it that way.

- *Michael Mantai*

Don't I already pay for that?

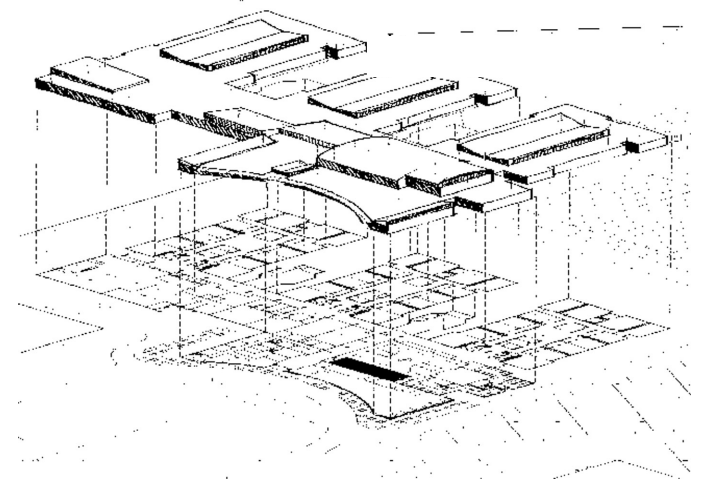


**MIND THE GAP**

# Need for Commissioning

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- ◆ New environment for construction
  - ◆ Green buildings/energy efficiency
  - ◆ Less skilled labor
  - ◆ Limited Designer Oversight
  - ◆ Faster schedules
  - ◆ Complicated Systems
  - ◆ System Integration
  - ◆ Cheaper materials
  - ◆ Attention to Indoor Air Quality
  - ◆ Mold Concerns



# Need for Commissioning

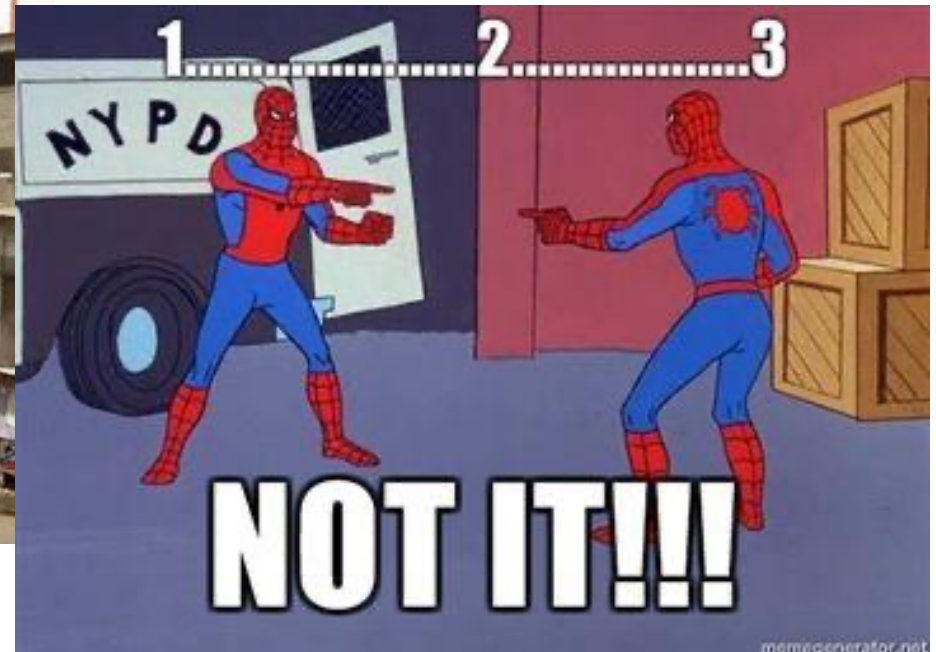
End result is often:

- ◆ Projects occupied before proper “functional” completion
- ◆ Delayed projects
- ◆ Problematic systems
- ◆ Poor indoor air quality and sick buildings
- ◆ Costs to Owner to troubleshoot and fix problems
- ◆ Excess Energy Use/High Utility Bills
- ◆ Owner not properly trained and equipped with information to maintain building



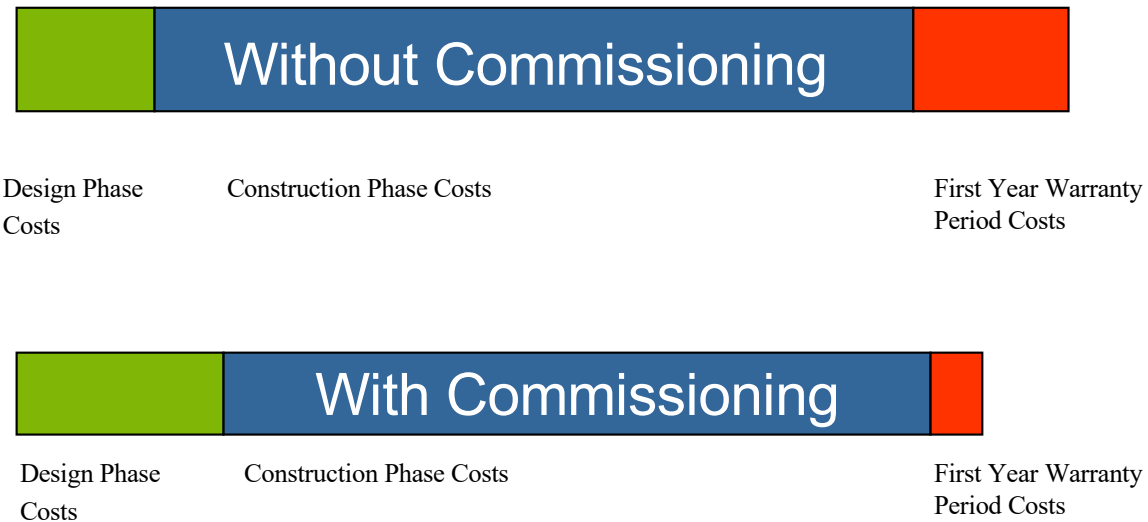
# Bottom Line

No party is actually responsible to make sure the building works.



# The Economics of Commissioning

If planned correctly and implemented early enough in the design process, commissioning can be included with little or no cost impact\*.



\* Based on research findings from University of Wisconsin, ASERTTI Training Module, 1998

# Who Does Commissioning?

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- ◆ Design Team
- ◆ Owner
- ◆ Contractor
- ◆ Third Party Consultant
- ◆ Mix of Above

# Who Requires Commissioning?

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- ◆ LEED® (Required + Optional Points)
- ◆ Green Globes® (Optional Points)
- ◆ SC Law (State building > 10,000 SF must be LEED® or Green Globes® certified; with exceptions)
- ◆ International Energy Conservation Code

# Basic Commissioning Process

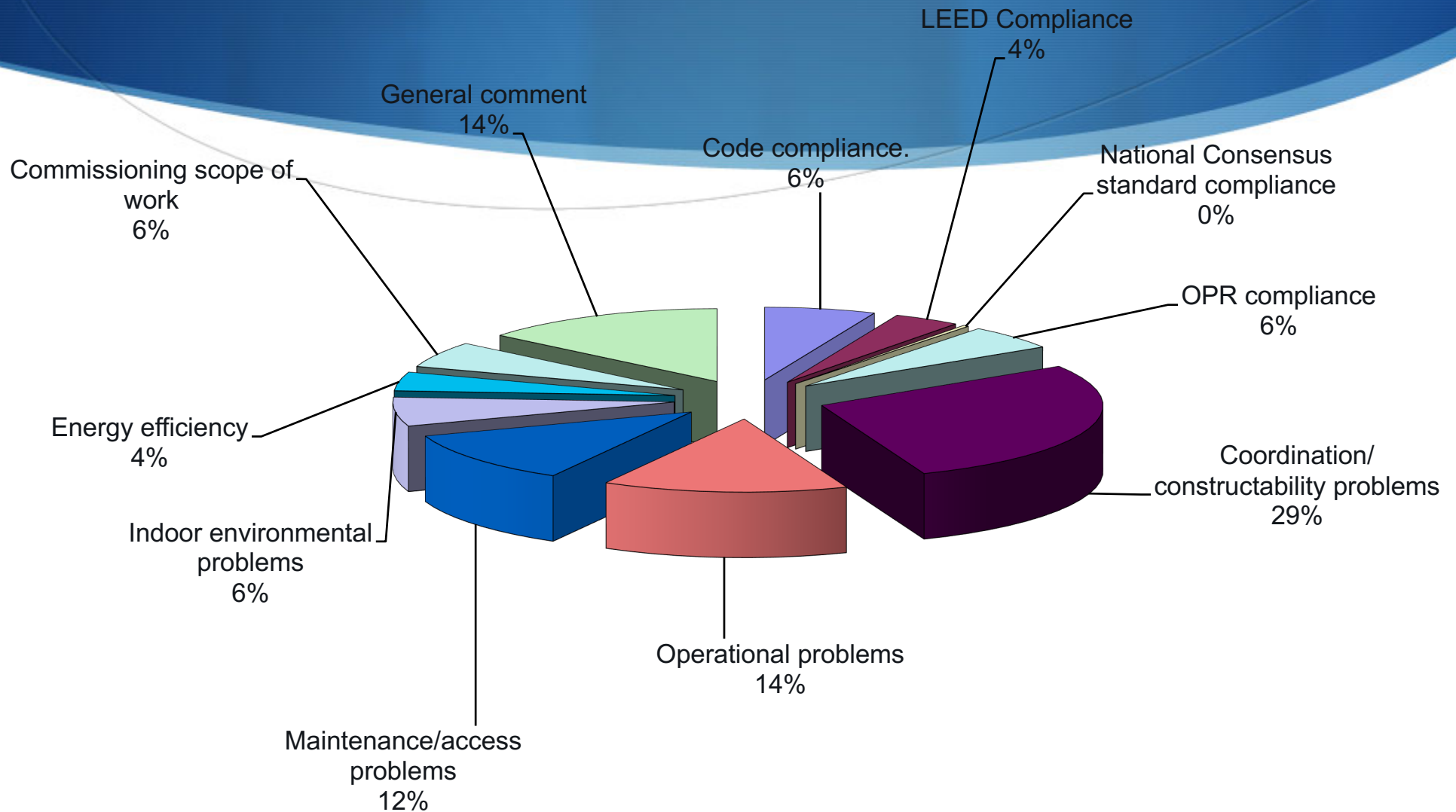
- ◆ Establish Owner's Project Requirements
- ◆ Design Review
- ◆ Commissioning Specifications
- ◆ Submittal Reviews
- ◆ Site Visits
- ◆ Construction Checklists
- ◆ Functional Testing
- ◆ O&M/Training
- ◆ Opposed Season Testing/Warranty Review

# Challenges

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- ◆ Design Team responsiveness
- ◆ Contractor participation/responsiveness
- ◆ Conflict Resolution
- ◆ Construction schedule
  - ◆ Compression of activities at end
  - ◆ Stacking of trades
  - ◆ System preparation

# Typical Findings



# Clemson University Douthitt Hills



CLARK NEXSEN



# Clemson University Douthit Hills

- ◆ Largest capital project in Clemson's history
- ◆ 700,000+ SF, \$180 million
- ◆ Seven new residence halls
- ◆ Central Hub building with food service, fitness center
- ◆ Central Chiller Plant
- ◆ Chilled Beams/FCUs coupled with DOAS
- ◆ LEED® Silver Certified



# Clemson University Douthit Hills

		be provided for each balancing damper?	
18.	ME2.01	In our experience, a recurring issue with fan coil units located in closets is access to all components requiring service and inconsistency in the way contractors install ductwork, piping, disconnects, controls, etc. We recommend a detail be provided illustrating how and where all the various components are intended to be located, and also require a mockup be constructed, reviewed, and approved by the project team prior to installing other units. This is typical of all buildings with fan coil units.	COORD MAINT
19.	ME2.01	No ventilation apparent for corridors (typical all buildings in both zones). Note that ASHRAE 62.1 is a LEED® prerequisite and it requires ventilation for corridors.	
20.	ME2.02	Outside air louver located at 2 <sup>nd</sup> level will be difficult to access if needed for cleaning or other issues. Consider an alternate accessible location for an outside air intake.	
21.	MF2.01	No ventilation apparent for storage rooms (typical all buildings in both zones). Note that ASHRAE 62.1 is a LEED® prerequisite and it requires ventilation for storage rooms.	

Submittal Review Comments				
Project: Clemson University - Douthit Hills				
Project Number:				
Date: 5/24/16				
Comment No.	Date	Submittal #	Submittal Name	Comment
1		001-223400-00	East - Fuel Fired Domestic Water Heaters	223400-2.1.A.3.h appears to require BACNet interface; option not indicated on submittal.
2		001-230519-00	East - Meters Gages for HVAC Piping PD	Ranges for pressure gauges are not indicated.
3		001-232123-01	East Zone - Hydronic Pumps Product Data	Pump motors need to be Inverter Duty Rated for use with VFDs.
4				Commissioning design review comments included recommending Premium Efficiency motors and shaft grounding rings.
5		001-233300-00	East - Air Duct Accessories PD	Volume dampers in insulated duct systems should have 2" standoff per 233300-3.1.E.
6		001-232923-01	East REVISION 1 - Variable Frequency Motor Controllers PD	Submittal only includes air handling units. VFDs are also required for Relief Fans and Pumps. Will those also be provided by JCI, and if so will they be submitted separately?
7		001-233423-00	East - HVAC Power Ventilators PD	RF-E1 indicates it will be provided with a shaft grounding ring [recommended for all motors driven by VFD]. But the other relief fans do not indicate a shaft grounding ring.
8		001-233713-00	East Zone - Diffusers Registers Grilles Product Data	Cx design review comment was to omit OBD where duct-mounted balancing dampers were provided; OBD's can create unwanted noise.
9		001-237313-01	East REVISED REVISION 1 - Air Handling Units	Fan RPM requirements will necessitate operating VFDs in excess of 60 Hz. We have seen evidence on recent projects that this can be detrimental to motor life and result in premature motor failure.
10				Control dampers submitted as parallel-blade; should be opposed-blade?
				Required condensate drain trap height is 11". Confirm that base rail the breakaway pad height allows for installation of trap.

# Clemson University Douthit Hills

## INSTALLATION CHECKLIST

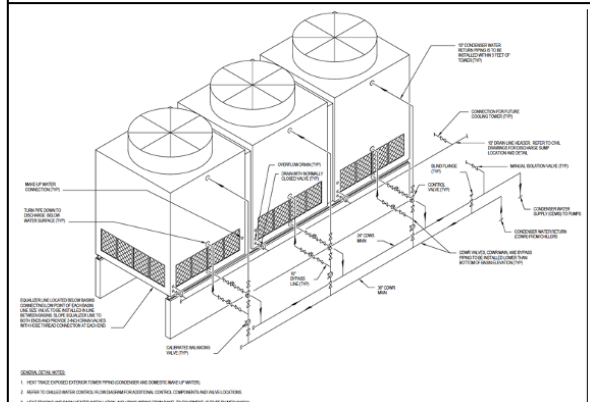
<b>Condenser Water System</b>	Clemson University - Douthit Hills Student Community, System WorCx Project No. 12013
Equipment Type:	Cooling Tower and Condenser Water Pumps

### Cooling Tower Installation

<b>General Install</b>	General installation checks. Typical of all projects.	CT-1	CT-2	CT-3	Notes
General condition of cooling tower acceptable					
Located to allow sufficient airflow through intakes - clearance to walls and equip.					
Tower support steel properly installed and in good condition					
Seismic restraint provided - unit bolted down securely.					
Tower installed level and plumb					
Fan belt tension correct					
Fans and motors lubricated					
Fan guard installed					
Air inlet screens and/or louvers in place					
Tower basin sump strainers clean and sump filled					
No apparent leakage detected after tower is filled					
Railings, platforms, ladders provide appropriate access to tower components					
For dual towers - equalizer piping installed with valve to isolate individual towers					
Pipe fittings, connections, and accessories installation complete					
Make-up water piping complete, including make-up water control valve/solenoid					
System properly flushed/cleaned and chemical treatment added					
Power connection complete to all components - motors, basin heater, heat tape, etc					

### Drawing/ Spec Requirements

Project specific requirements extracted from construction drawings, project specs, and approved submittals.



Item of Verification	Method	Verify	ERV-A1	Notes
OFF MODE	Command unit OFF through BAS	Supply fan is OFF.	X	
		Exhaust fan is OFF.	X	
		Chilled water control valve is CLOSED	X	
		Preheat control valve is CLOSED	X	
		Reheat control valve is CLOSED	X	
		Outside air damper is CLOSED	X	
		Exhaust air damper is CLOSED	X	
ON MODE	Command unit ON through BAS	Supply fan is ON.	X	
		Return fan is ON.	X	
		Outside air damper is OPEN to minimum position	X	
		Return air dampers are OPEN	X	
Pre-Heat Coil Control	Temporarily adjust setpoints so that AHU DAT is lower than setpoint.	Verify preheat coil control valve MODULATES to maintain AHU DAT setpoint. Verify no hunting (deviation of more than 1F from setpoint after 30 second stabilization time). If hunting is observed, BAS contractor should tune PID loop and retest.	X	
Cooling Coil Control	Temporarily adjust setpoints so that AHU DAT is higher than setpoint.	Verify cooling coil control valve MODULATES to maintain AHU DAT setpoint. Verify no hunting (deviation of more than 1F from setpoint after 30 second stabilization time). If hunting is observed, BAS contractor should tune PID loop and retest.	X	
Re-Heat Coil Control	Temporarily adjust setpoints so that AHU DAT is lower than setpoint.	Verify reheat coil control valve MODULATES to maintain AHU DAT setpoint. Verify no hunting (deviation of more than 1F from setpoint after 30 second stabilization time). If hunting is observed, BAS contractor should tune PID loop and retest.	X	

Issue #	Date Ident	Ident-iff	System(s)	Issue	Resp. Part	Issue Code	Resolution	Ref. Doc	Date Confirmed
				which duct. Recommend labeling all flow stations in the EAST buildings. See SPEC for labeling details.					
230	11/7/17	CA	MECH	Exhaust air direction of flow labeling is incorrect on AHU-E1 & E2. Recommend correcting to prevent confusion.		MAINT	Corrected		11/30/17
231	11/7/17	CA	BAS	AHU-E1 supply airflow station reads 2094 cfm when the unit is OFF. It appears that an offset was entered to calibrate the unit. Calibration should be done by adjusting unit (Ebtron AFS) GAIN and not with an offset. Airflow is not linear and therefore an offset would only prove accurate at max flow conditions.		OPS	Corrected		11/30/17
232	11/7/17	CA	MECH	AHU-E1 relief duct is severely deformed near the relief isolation dampers. The dampers located at this location are also not installed fully perpendicular to the duct and appear to allow for leakage. Verify damper is correctly installed and can fully function.		OPS	Repaired by mechanical contractor.		1/9/18
233	11/7/17	CA	BAS	General Note: In several locations control wires are not properly secured inside the AHU's. Recommend securing wires to prevent being damaged.		OPS	Corrected		11/30/17
234	11/7/17	CA	BAS	AHU-E1 (S1) supply fan VFD bypass button is broken. Recommend repairing.		OPS	Repaired		1/9/18
235	11/7/17	CA	BAS/ MECH	Exhaust and Supply fans located in AHU's in Building E&F have (1) fan that have the incorrect rotation when in bypass. It appears that the start-up technician failed to test fan rotations while in bypass. (Rotation is correct in VFD) Recommend verifying all units in the EAST have the correct rotation. All AHU's have counter rotating fans that rotate towards center.		OPS	Corrected		11/30/17
236	11/7/17	CA	MECH	Building E basement mechanical room has several hot water pipe insulation shields that are not installed.		OPR	Corrected.		1/9/18
237	11/7/17	CA	FIRE SP, MECH	General Note: Building E basement mechanical room several of the sprinkler, heating water pipe and duct down rods are loose and need to be adjusted.		OPR	Rods adjusted.		1/9/18
238	11/7/17	CA	MECH	AHU-E2 has not been anchored to the house keeping pad. Recommend securing unit.		OPR	Repaired.		1/9/18
239	11/7/17	CA	MECH	General Note: Building E AHU's are extremely dusty inside and have debris in the drain pans. Several AHU heat wheels are becoming excessively dirty because of this condition. Recommend cleaning all units in the EAST.		OPS	Corrected		11/30/17
240	11/7/17	CA	BAS	AHU-E2 relief airflow station reads 1157 cfm when the unit is OFF. It appears that an offset was entered to calibrate the unit. Calibration should be done by adjusting unit (Ebtron AFS) GAIN and not with an offset. Airflow is not linear and therefore an offset would only prove accurate at max flow conditions. Also note: one probe in damaged and needs to be repaired.		OPS	Corrected		11/30/17
241	11/7/17	CA	BAS	AHU-E2 relief fan VFD is not correctly labeled. Recommend correcting to reflect contract documents.		OPR	Corrected.		1/9/18
242	11/7/17	CA	BAS	AHU-E2 was found to be able to operate in bypass when the alarm circuit was tripped. Recommend correcting this to prevent unit operation while in alarm.		OPS	Corrected		11/30/17

490  
issues  
resolved

# Owner's Perspective

Tony Putnam, P.E., CEFP

Director of Utility Services



# Recommissioning

## SC ENERGY INDEPENDENCE AND SUSTAINABLE CONSTRUCTION ACT OF 2007:

*All major facility projects that were certified...must be inspected by a third-party commissioning agent in the fifth, tenth, and fifteenth year following certification.*

# Why Recommission?

Almost 75% of the increase in energy use was caused by significant component failures and/or control changes (related to other building problems)...the remainder was due to control changes implemented by the operators.

- Excerpt from 12/04 study



# Why Recommission?

	National Energy Waste (Quads, primary/year)	Electricity equivalent (BkWh/year)	Cost (\$billion/year)
Duct leakage	0.3	28.6	2.9
HVAC left on when space unoccupied	0.2	19.0	1.9
Lights left on when space unoccupied	0.18	17.1	1.7
Airflow not balanced	0.07	6.7	0.7
Improper refrigerant charge	0.07	6.7	0.7
Dampers not working properly	0.055	5.2	0.5
Insufficient evaporator airflow	0.035	3.3	0.3
Improper controls setup / commissioning	0.023	2.2	0.2
Control component failure or degradation	0.023	2.2	0.2
Software programming errors	0.012	1.1	0.1
Improper controls hardware installation	0.01	1.0	0.1
Air-cooled condenser fouling	0.008	0.8	0.1
Valve leakage	0.007	0.7	0.1
Total (central estimate)	1.0	94.6	9.6
Total (range)	0.34-1.8	32.4-171.4	3.3-17.3

# Typical Recommissioning Activities

- ◆ Observe system components
- ◆ Check sensor calibrations
- ◆ Retest controls sequences
- ◆ Review BAS for obvious issues

*Bottom Line: Verify building still performing at same level.*

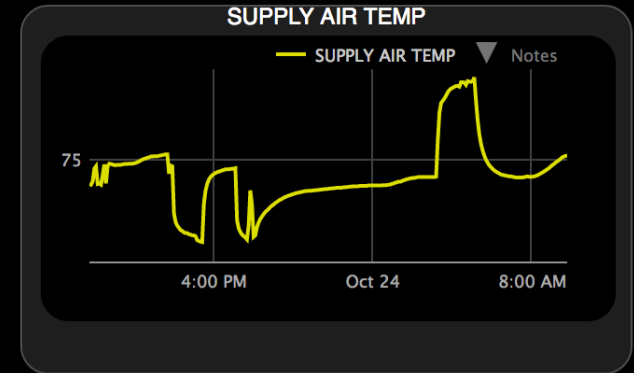
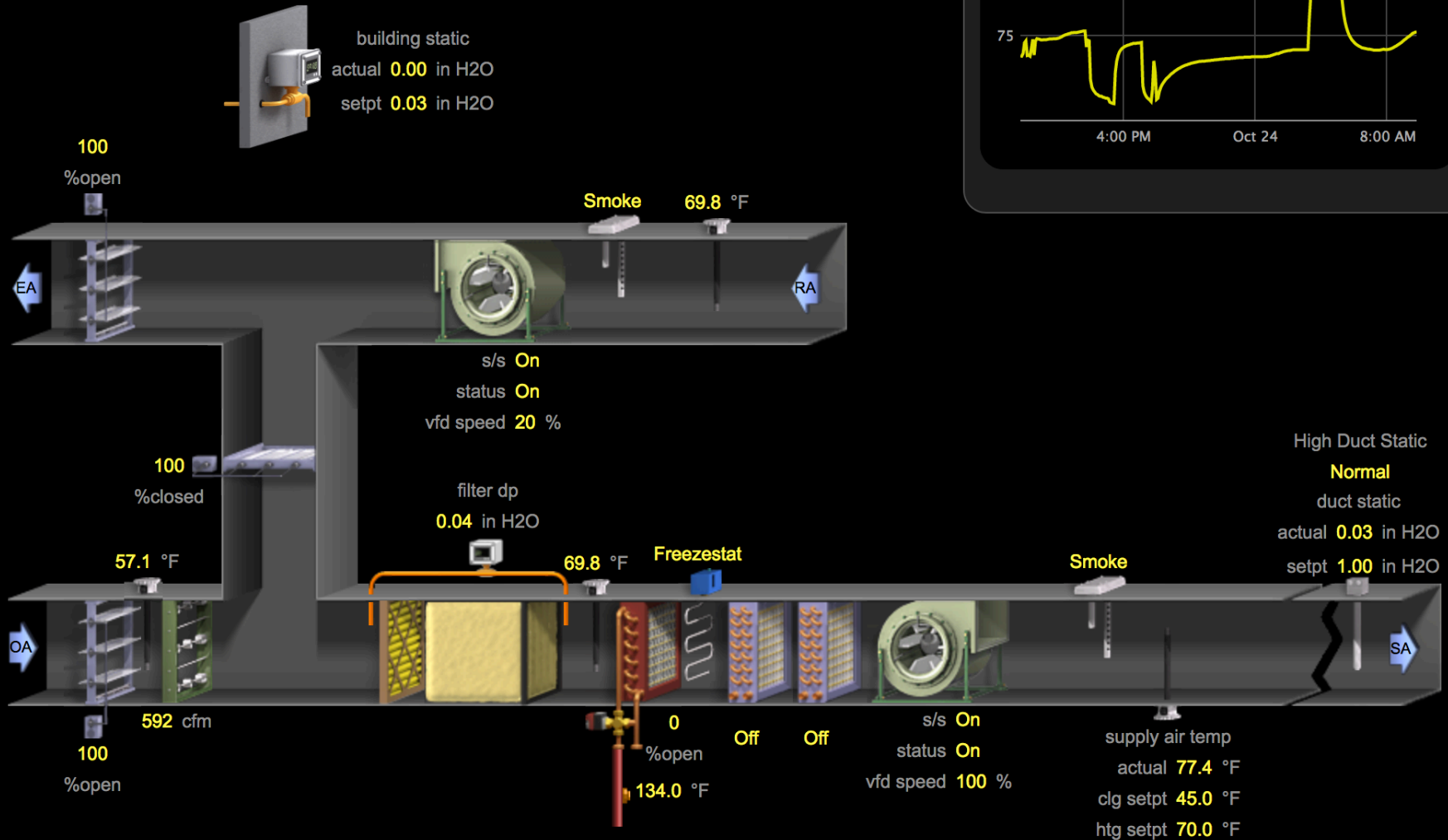
# Typical Recommissioning Findings

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- ◆ HVAC Systems programmed to operate 24/7.
- ◆ Operator Overrides of outside air dampers.
- ◆ Operator Overrides of heating/cooling control valves, fans, etc.
- ◆ Operator Overrides of setpoints.
- ◆ Broken, stuck, leaking control valves
- ◆ Over/Under Ventilation (Improper outside air control)

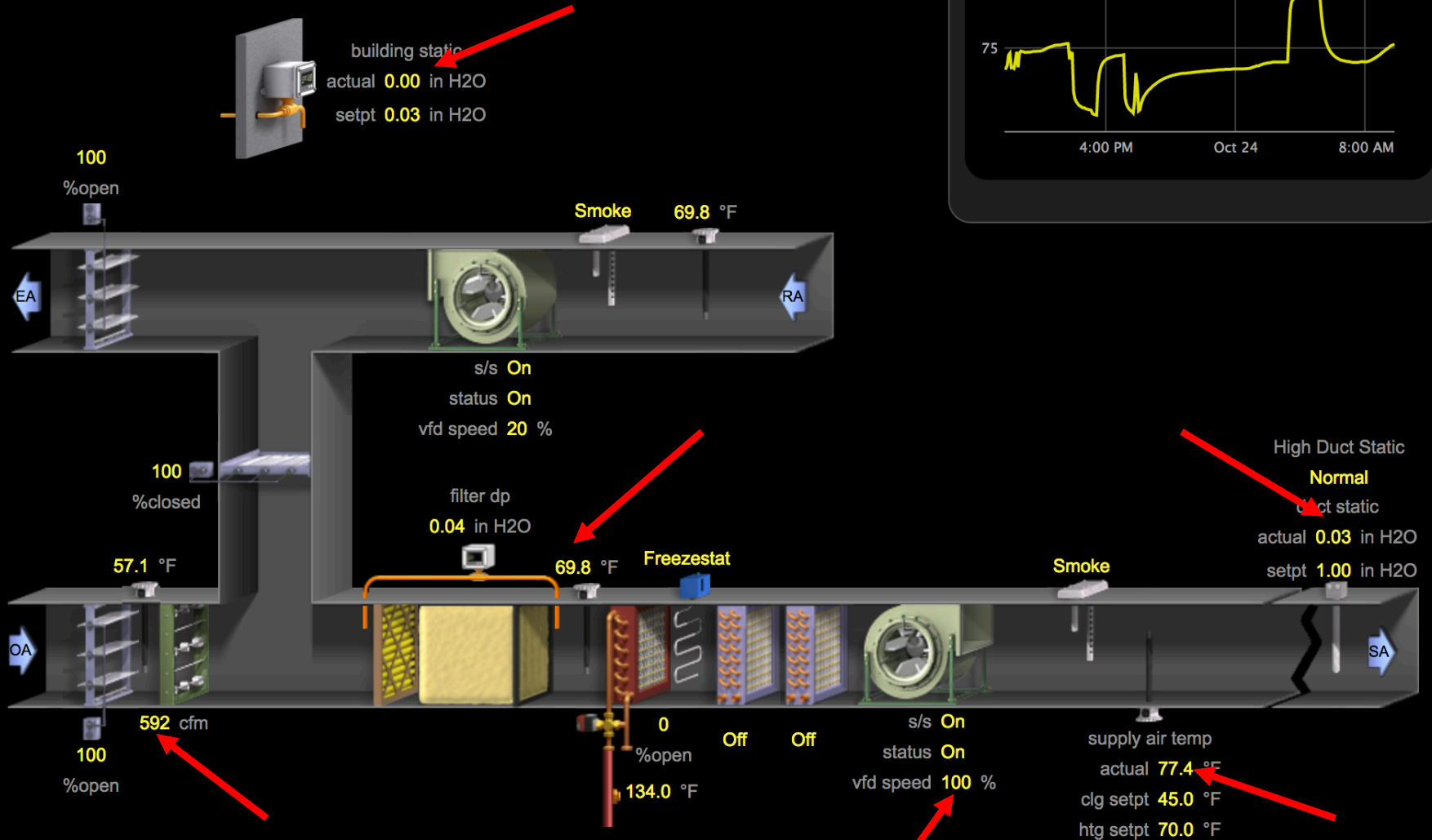
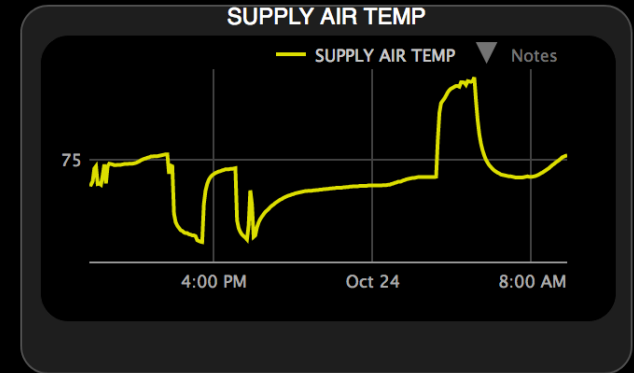
47.0 °F  
83 %rh

AHU-1 VAV B-172



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# Trends in Commissioning

- 💧 Air Leakage
- 💧 Water Leakage
- 💧 Thermal Performance



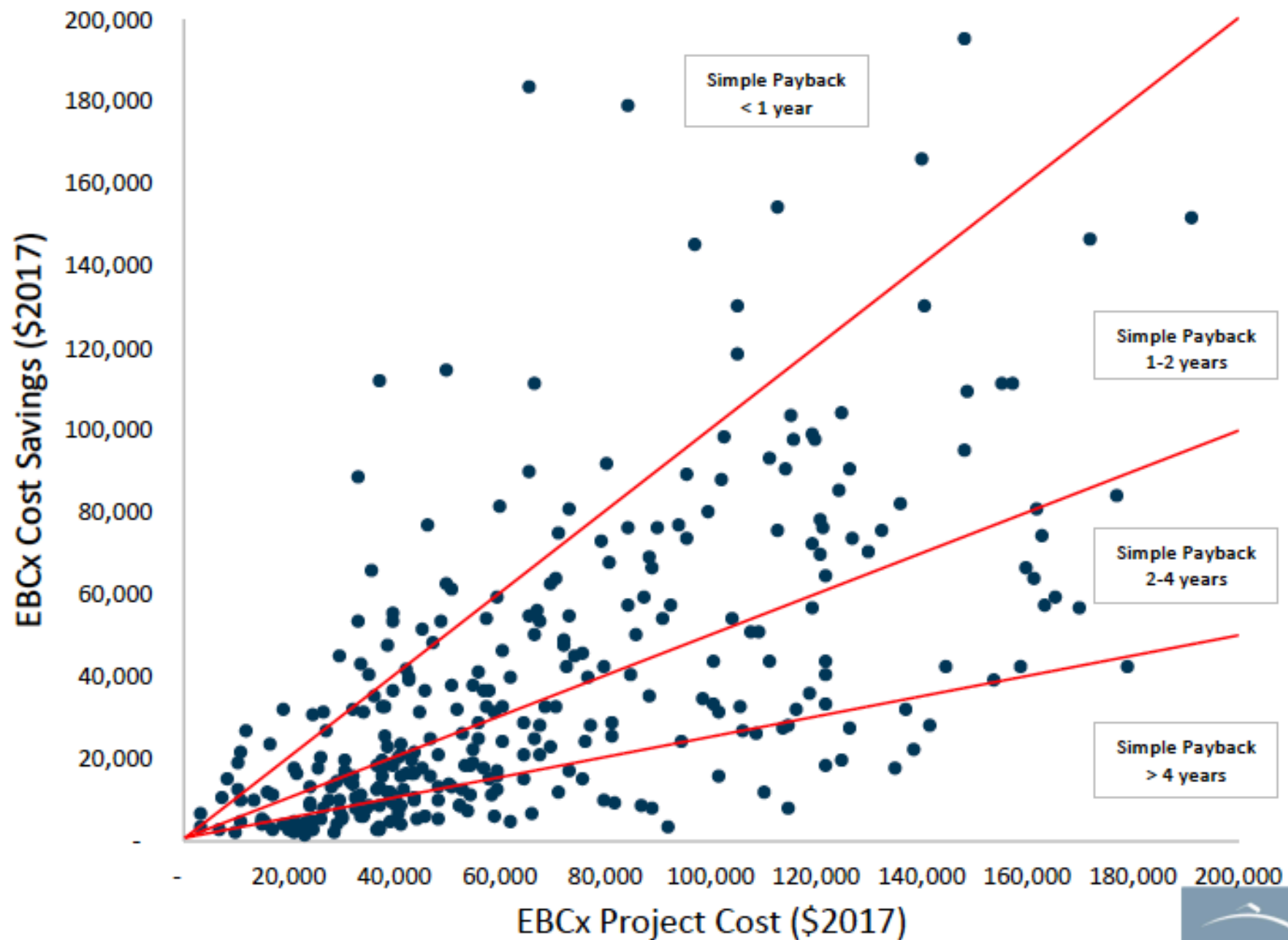
# Trends in Commissioning

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## Existing Building Cx (aka Retrocommissioning)

- ◆ Buildings:
  - ◆ 41% of energy use
  - ◆ 38% of CO<sub>2</sub> output
- ◆ Est. 1-2 BILLION existing buildings in the world.
- ◆  $\approx$  73,000 LEED® projects

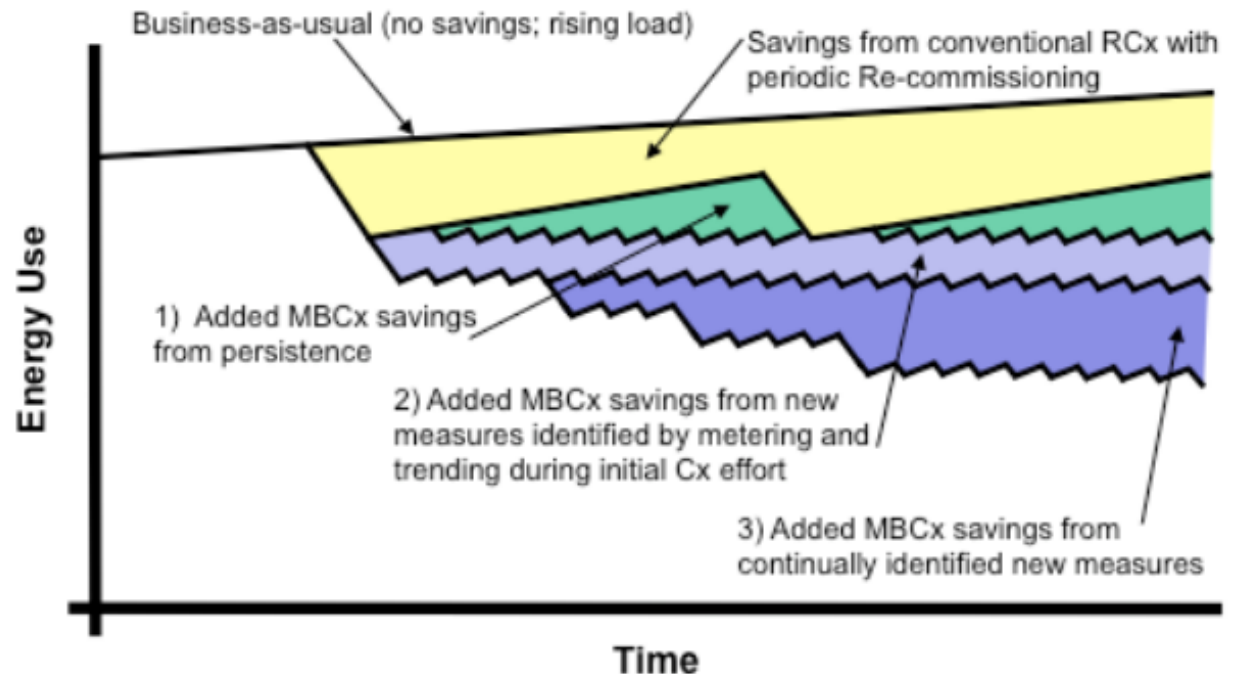
## EBCx Costs vs. Savings (\$2017)(<\$200,000)



# Trends in Commissioning



- Monitoring-Based Cx
- Continuous Cx
- FDD: Fault Detection and Diagnosis



# Questions



System WorCx

Building Performance at the Next Level